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Magnetic properties of $(La_{0.7}Sr_{0.3}MnO_3)_x(CaCu_3Ti_4O_{12})_{1-x}$ nanostructured composites

T.P. Gavrilova [a, b, *], R.M. Eremina [a, b], I.V. Yatsyk [a, b], I.F. Gilmutdinov [b], A.G. Kiiamov [b], N.M. Lyadov [a, b], Yu.V. Kabirov [c]

[a] Kazan E. K. Zavoisky Physical-Technical Institute (KPhTI) of the Kazan Scientific Center of the Russian Academy of Sciences, Sibirsky Tract, 10/7, Kazan, 420029, Russia
[b] Kazan (Volga Region) Federal University, Kremlevskaya Str., 18, Kazan, 420008, Russia
[c] Southern Federal University, Bolshaya Sadovaya Str., 105/42, Rostov-on-Don, 344006, Russia

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A B S T R A C T

$(La_{0.7}Sr_{0.3}MnO_3)_x(CaCu_3Ti_4O_{12})_{1-x}$ ($0.01 \le x \le 0.3$) nanostructured composites with $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) microinclusions in $CaCu_3Ti_4O_{12}$ (CCTO) matrix were synthesized using a solid state method. The structural and microstructural details were studied by X-ray diffraction (XRD), X-ray fluorescence (XFA), scaning electron microscope (SEM) and transmission electron microscope (TEM) techniques. The magnetic properties were studied by electron spin resonance (ESR) and magnetometry methods. In the concentration range $0.01 < x < 0.1$ physical properties of composites differ from the properties of the individual components CCTO or LSMO. The Curie temperature of the ferromagnetic phase for all concentrations is $T_C = 315$ K, that is less at 50 K than in pure LSMO. The Weiss constant of the paramagnetic phase has the strong concentration dependance. The observed mutual influence on the magnetic properties of both components can be tentatively attributed to the interface exchange interactions between them, hinting a possible magnetic proximity effect.

1. Introduction

Composite materials attract much attention due to the possibility to create the new structure combining the components with high values of the magnetic susceptibility and dielectric permittivity in different component proportions, because they can be used in variety of applications. They exhibit unexpected new physical properties, which can depend on the synthesis method and the internal structure of the composite. The ideal dual-phase $(Bi_4Ti_3O_{12})_x(CaCu_3Ti_4O_{12})_{1-x}$ ($x = 0$–1.0) composite system with separate orthorhombic and cubic phases gives a high dielectric constant ($\varepsilon' > 3000$) at 100 Hz at room temperature for $x = 0.8$. According these data it is revealed that these composites can be applicable for the fabrication of miniaturized global positioning system (GPS) patch antennas [1]. The high density well-crystallized $(Na,K)NbO_3$-$CaCu_3Ti_4O_{12}$ composites can be used as supercapacitor for possible application in piezoelectric devices [2]. Nanocomposite systems consisting of Fe_3O_4 nanoparticle-loaded porous silicon are of potential merit in the area of magnetically guided drug delivery [3]. Special attention is paid to the core-shell structured composites. The excellent review about the applications of exchange coupled bi-magnetic hard/soft and soft/hard ferromagnetic core/shell nanoparticles in the field of permanent magnets, recording media, microwave absorption, biomedical applications was published earlier [4].

Usually, multicomponent composite materials demonstrate magnetic, dielectric and electric properties differ from the properties of the individual components and the variation of the type of the internal structure of the composite (homogenized, granular or core-shell structure) can lead to the improving of these properties. So $(Bi_{0.5}Na_{0.5}TiO_3)_{0.5}(CaCu_3Ti_4O_{12})_{0.5}$ ($BNT_{0.5}CCTO_{0.5}$) exhibits high dielectric constant (ε~6.9×10^4) compared with BNT (ε~0.13×10^4) and CCTO (ε~1.68×10^4) ceramics at 1 kHz and 503 K, that is associated with a major contribution from grain boundaries, as confirmed by impedance analysis [5]. The dielectric constant of $(BaTiO_3)_{0.9}(CaCu_3Ti_4O_{12})_{0.1}$ sintered for 3 h exhibits very high values also because of the presence of semiconducting grains with

* Corresponding author. Kazan E. K. Zavoisky Physical-Technical Institute (KPhTI) of the Kazan Scientific Center of the Russian Academy of Sciences, Sibirsky Tract, 10/7, Kazan, 420029, Russia.
E-mail address: tatyana.gavrilova@gmail.com (T.P. Gavrilova).

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